

Two flavonoids (IV and V) present in trace amounts have been partially characterized as apigenin *C*-pentoside (IV) and methoxyapigenin *C*-pentoside (V) by electrospray mass spectra (positive mode) which showed a quasimolecular ion $[M+H]^+$ at m/z 403 and a quasimolecular ion $[M+H]^+$ at m/z 433 respectively and fragment ions typical of flavone *C*-pentosides (Cabrera, 2006); in addition flavonoid (V) was different from vitexin and isovitexin in paper chromatography. UV spectral analysis with the customary shift reagents and R_f values in paper chromatography were in agreement with the above partial structures.

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The Genus *Cystopteris* at Waterfall Glen Forest Preserve, DuPage County, Illinois.—The genus *Cystopteris* (Woodsiaceae) is among the most taxonomically difficult in the temperate North American flora, comprising three extant and one as yet undiscovered diploid species and a complex series of sterile and fertile polyploid hybrid derivatives (Haufler *et al.*, in *Flora of North America* Editorial Committee, eds., *Flora of North America North of Mexico* 2: 263–270. Oxford University Press, New York, 1993). The genus is well represented in the state of Illinois, with six fertile taxa and one sterile hybrid documented until now in the floristic literature (Mohlenbrock, *The Illustrated Flora of Illinois. Ferns*. 2nd ed. Southern Illinois University Press, Carbondale, 1999; *Vascular Flora of Illinois*. Southern Illinois University Press, Carbondale, 2002).

In conjunction with the Botany and Plant Biology 2007 Joint Conference that was held in July, 2007, in Chicago, the authors were among those tasked by the American Fern Society (AFS) to plan and carry out two days of fern forays in the region for members participating in the conference. Given the relatively high diversity of *Cystopteris* taxa reported from northern Illinois, special attention was paid to locating interesting populations of this genus at the sites that we were planning to visit.

Among the properties selected for study during the 2007 AFS fern foray was Waterfall Glen Forest Preserve, located in the DuPage County portion of the Chicago metropolitan region, on the south side of Interstate 55 near the suburb of Darien. From an initial 75-acre purchase in 1925, the site has grown to about 2,488 acres surrounding the Argonne National Laboratory. It is an island of natural habitat in a sea of urban development. The property, which is managed both for recreational use and for its natural features by the Forest Preserve District of DuPage County, is home to more than 1,000 vascular plant species, more than two thirds of the total known flora of the county, including three lycophyte and 17 fern species.

One of the most interesting areas within the preserve is Rocky Glen (41° 42' 19" N, 087° 57' 53" W, elev. 180–200 m). This site contains a rock-walled limestone drainage in a mesic upland hardwood forest with mostly intermittent water flow and a year-round, humid, sheltered microclimate. The drainage empties over a scenic, overhung waterfall, with numerous ledges and crevices of varying exposure. The more exposed ledges surrounding the waterfall are home mostly to *Cystopteris* taxa and *Pellaea glabella* Kuhn ssp. *glabella*.

Prior to the 2007 AFS foray, *C. bulbifera* (L.) Bernh. and *C. protrusa* (Weath.) Blasdell were the only *Cystopteris* species on the preserve's floristic checklist. *Cystopteris protrusa* is common on the forest floor along the mesic upland slopes surrounding the ravines, and *C. bulbifera* was thought to be the common member of the genus on limestone outcrops in the preserve. On June 16, 2007, when the authors visited the preserve accompanied by Carl Taylor, Ken Klick, and Eric Ulaszek, we encountered a large, dense population of *Cystopteris* on the rock faces and ledges in the sheltered Rocky Glen drainage in the stretch above the waterfall. This population exhibited considerable variation in frond morphology, which suggested that more taxa were to be found at the site than had been reported in the past. Two mature fronds that did not appear to represent *C. bulbifera* were harvested for later study. Much to our surprise, both of these fronds turned out to have produced only abortive spores and thus represent sterile hybrids. Morphological comparisons using the characters in the Flora of North America treatment (Haufler *et al.*, in Flora of North America Editorial Committee, eds., Flora of North America North of Mexico 2: 263–270. Oxford University Press, New York. 1993) suggested that these unusual fronds might represent the unnamed sterile tetraploid hybrid between *C. fragilis* and *C. tenuis* (Michx.) Desv., a suggestion that received preliminary support when we asked an authority on North American *Cystopteris* (Michael D. Windham, Duke University, pers. comm.), to examine the collection. This hybrid between two morphologically cryptic tetraploid parents had been analyzed in detail by Paler and Barrington (Syst. Bot. 20: 528–545. 1995), based on populations in Vermont. However, because neither of the presumed parents of our hybrid fronds had ever been reported from DuPage County, we felt it prudent to perform further field studies.

During the AFS foray on July 7, 2007, the nearly 30 participants were encouraged to seek out individual plants with unusual morphologies at Rocky Glen. From these finds, a series of 15 sporulating fronds was collected to represent the morphological diversity of *Cystopteris* in the mixed-taxon population in the drainage. These carefully pressed samples were studied at the Missouri Botanical Garden and compared to data from the literature, as well as to known vouchers in the MO herbarium that had been annotated by Chris Haufler and his colleagues during their biosystematic studies of the genus (Haufler *et al.*, Ann. Missouri Bot. Gard. 77: 314–329. 1990; Haufler and Windham, Amer. Fern J. 81: 7–23. 1991). Robbin Moran (New York Botanical Garden, pers. comm.) subsequently examined this larger set of fronds and kindly verified our conclusions.

The results of these studies document the following taxa for the Waterfall Glen Forest Preserve in DuPage County, Illinois (vouchers are accessioned variously at MO and/or MOR, as indicated):

Cystopteris bulbifera (L.) Bernh. — This fern is common in the mixed-species population of fragile ferns growing on the limestone walls and crevices of the Rocky Glen drainage. It also occurs on limestone outcrops below the waterfall and elsewhere in the preserve. Voucher: *Yatskievych et al. 07-95* (MO).

Cystopteris protrusa (Weath.) Blasdell — As noted above, this fern is a conspicuous member of the spring flora occurring on the forest floor along the mesic upland slopes surrounding the ravines an essentially throughout the wooded portions of the preserve. Voucher: *Kobal SNK 08-03* (MO).

Cystopteris fragilis (L.) Bernh. — This fern is scattered in the mixed-species population of fragile ferns growing on the limestone walls and crevices of the Rocky Glen drainage. Only two of the “non-*bulbifera*” fronds that were harvested during the foray represented this taxon. Within the context of the fragile ferns at the Rocky Glen portion of the Waterfall Glen Forest Preserve, *C. fragilis* was noteworthy in its combination of the following morphological attributes: fronds with a relatively slender lamina broadest well above the base and sharply toothed segment margins, as well as relatively small sori and the absence of glands anywhere on the laminar or indusial tissue.

Swink and Wilhelm (1994) excluded *C. fragilis sensu stricto* from the flora of the Chicago Region, but Mohlenbrock (The Illustrated Flora of Illinois. Ferns. 2nd ed. Southern Illinois University Press, Carbondale. 1999; Vascular Flora of Illinois. Southern Illinois University Press, Carbondale. 2002) indicated that it occurs in Lake and McHenry Counties. Our specimen vouchers a new report for the preserve checklist and for DuPage County. Voucher: *Yatskievych et al. 07-97* (MO, MOR).

It should be noted that we were unable to discover any plants determinable as *C. tenuis* (Michx.) Desv. at Waterfall Glen despite our field studies in a small area, based on the subtle morphological differences discussed by Haufler *et al.* (in Flora of North America Editorial Committee, eds., Flora of North America North of Mexico 2: 263–270. Oxford University Press, New York. 1993) and Paler and Barrington (Syst. Bot. 20: 528–545. 1). Our fronds had the pinnae relatively straight and spreading from the rachis at a ca. 90° angle (vs. curved upward and departing from the rachis at an acute angle), distal pinnae mostly narrowly deltate (vs. ovate to narrowly elliptic), and basal basisopic pinnules of the proximal pinnae mostly rounded to truncate (vs. cuneate to rounded) (Haufler *et al.*, in Flora of North America Editorial Committee, eds., Flora of North America North of Mexico 2: 263–270. Oxford University Press, New York. 1993). Interestingly, the fronds in our sample produced sparse, multicellular, nonglandular trichomes on the rachis (perhaps representing reduced scales) abaxially near some of the pinna attachments, which is atypical in both *C. fragilis* and *C. tenuis*.

Moran (Amer. Fern J. 72: 41–44. 1982a) mapped *C. tenuis* from scattered counties in both northern and southern Illinois, but did not show any

occurrences in the Chicago region in Illinois. However, Swink and Wilhelm (1994) documented a single population from Lake County (as *C. fragilis* var. *mackayi* G. Lawson). Mohlenbrock (The Illustrated Flora of Illinois. Ferns. 2nd ed. Southern Illinois University Press, Carbondale. 1999) added a report for McHenry County. Further searches in the region are needed to better document the status of *C. tenuis* in northeastern Illinois.

Cystopteris tennesseensis Shaver — This fern is common in the mixed-species population of fragile ferns growing on the limestone walls and crevices of the Rocky Glen drainage. More than half of the “non-*bulbifera*” fronds that were harvested during the foray represented this taxon. It is morphologically variable, but characterized by the following combination of features: fronds having the lamina variously divided but generally broadest above the base, relatively large sori, and the presence of glands scattered unevenly along the rachis, the abaxial laminar tissue, and occasionally, the indusia. Plants often may be recognized in the field because even the smaller fronds are copiously fertile.

This is a new report for the preserve checklist, but not for DuPage County. Moran (Amer. Fern J. 72: 93–95. 1982b) mapped this species from scattered counties in Illinois, mainly from cliff areas along major streams and rivers. Swink and Wilhelm (1994) discussed that it occurs occasionally in limestone drainages along the Des Plaines River, including sites in Cook, DuPage, and Will Counties. Vouchers: *Yatskievych et al. 07-98* (MO, MOR), *Kobal FPD 07-16* (MOR).

Cystopteris cf. *fragilis* × *tenesseensis* — Plants occur uncommonly in the mixed-species population of fragile ferns growing on the limestone walls and crevices of the Rocky Glen drainage. Only the original two fronds harvested during our June visit to the preserve had abortive spores; no additional sterile plants were located during the July foray. Individuals that we originally thought might represent sterile hybrids between *C. fragilis* and *C. tenuis* now seem to fit better as hybrids between *C. fragilis* and *C. tennesseensis*, following our examination of a larger sampling of fronds in the mixed population and a more careful consultation of the literature and specimens at MO. This hybrid was included without a binomial in the reticulogram presented by Haufler *et al.* (in *Flora of North America* Editorial Committee, eds., *Flora of North America North of Mexico* 2: 263–270. Oxford University Press, New York. 1993), but we have not uncovered any literature reports discussing it or its distribution in further detail. Haufler *et al.* (Ann. Missouri Bot. Gard. 77: 314–329. 1990) did not report any samples attributable to this hybrid combination in their allozyme analysis of the *C. tennesseensis* complex. We caution that the identity of these sterile plants needs to be confirmed using non-morphological data. Voucher: *Yatskievych et al. 07-94* (MO).

Sterile hybrids in *Cystopteris* nearly always occur in close proximity to both parents. Given the fertile components of the fragile fern flora present at Rocky Glen, one might speculate that several possible hybrid combinations might be present, but some of these can be excluded relatively easily from further consideration. For example, *C. protrusa* grows in the general vicinity, but at

Rocky Glen is found only in soil on the wooded slopes above the rock-walled drainage and not on the rocks themselves.

We also suggest that *C. bulbifera* was not involved in the production of the hybrids in our sample. Moran (Castanea 48: 224–229. 1983b) noted that hybrids involving *C. bulbifera* were among the first to be described in the genus and are all relatively easily recognized, because primary hybrids involving that species almost always exhibit fronds with a similar shape and dissection pattern, as well as producing small, irregularly reduced bulblets, and have glandular trichomes. Bulblets and glands are totally lacking in the two sterile plants in our sample and the frond shape and division pattern are not reminiscent of *C. bulbifera*. Moran (Castanea 48: 224–229. 1983b) also noted that intertaxon hybrids in the genus that do not involve *C. bulbifera* as a parent are for more cryptic morphologically and had not been described prior to 1983.

The only other sterile hybrid in the complex reported from the Chicago region is *C. bulbifera* × *tenuis*. That hybrid combination was named as *C. ×illinoensis* by Moran (Amer. Fern J. 72: 41–44. 1982a), who described it from plants grown in the Rockford, Illinois, garden of Ralph Benedict, that had been transplanted in the 1960s from a natural, mixed population in a dolomite quarry in nearby Winnebago County. According to Mohlenbrock (The Illustrated Flora of Illinois. Ferns. 2nd ed. Southern Illinois University Press, Carbondale. 1999; Vascular Flora of Illinois. Southern Illinois University Press, Carbondale. 2002), this hybrid is still known only from the original collection. As would be expected from a primary hybrid with a *C. bulbifera* parent, *C. ×illinoensis* differs from our plants morphologically in producing small, abortive bulblets and sparse, glandular trichomes on fronds that tend to be broadest at the lamina base.

The first hybrid in *Cystopteris* not directly involving a *C. bulbifera* parent was named *C. ×wagneri* by Moran (Castanea 48: 224–229. 1983b), based on his study of a mixed-species population between *C. tennesseensis* and *C. tenuis* in Fairfield County, Ohio. It has not been reported from Illinois. The two sterile plants in our sample closely resemble those described as *C. ×wagneri* by Moran (Castanea 48: 224–229. 1983b), having only slightly less divided pinnae that are straight rather than slightly arched acroscopically. Also, Moran reported that plants of *C. ×wagneri* can produce sparse glandular trichomes, but we observed none in the two sterile plants from Rocky Glen (admittedly a small sample size for such a subtle character). The apparent absence of *C. tenuis* from the mixed population at Rocky Glen also supports the contention that this taxon is not involved in the parentage of our sterile plants. However, given the great morphological similarity between *C. tenuis* and *C. fragilis* (Moran, Castanea 48: 218–223. 1983a; Haufler *et al.*, in Flora of North America Editorial Committee, eds., Flora of North America North of Mexico 2: 263–270. Oxford University Press, New York. 1993), this lends support to our hypothesis that the Rocky Glen hybrids might represent *C. fragilis* × *tenesseensis*.

Thus far, we have found no previous reports of the existence of the hybrid between *C. fragilis* and *C. tennesseensis* in Illinois, but we caution again that the parentage of the abortive-spored plants at Waterfall Glen needs to be confirmed using nonmorphological data such as analysis of allozyme variation or DNA markers. Although we have assembled circumstantial evidence to support a plausible case for the parentage of the sterile plants discovered at the preserve, further research will be necessary to develop a fuller understanding of this interesting mixed-species population in DuPage County, Illinois.—
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